DOCUMENT RESUME

ED 353 400 CE 062 808

AUTHOR Pucel, David J.
TITLE Technology Education: Its Changing Role within General Education.
PUB DATE 6 Dec 92
NOTE 32p.; Paper presented at the American Vocational Association Convention (St. Louis, MO, December 6, 1992). For a related document, see CE 062 807.
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Appropriate Technology; *Curriculum Development; General Education; Junior High Schools; Program Development; Science and Society; Scientific and Technical Information; *Technological Advancement; *Technological Literacy; *Technology Education; *Technology Transfer
IDENTIFIERS *Technological Methods

ABSTRACT

Changes in society and work have led to reconsideration of the role schools should play in preparing students to become technologically literate. Technological literacy is part of cultural literacy. Technologically literate people have common sense knowledge of technology, understanding how technology evolves to satisfy human needs. The role of evolving technology can be understood through the "technological method," which has the following steps: (1) identify an unmet human need requiring a technical solution; (2) clarify the specific technical problem; (3) identify relevant existing technical methods and knowledge; (4) invent a probable solution; (5) determine the social acceptability and economic feasibility of the solution; (6) modify the solution if needed to maximize efficiency and acceptability; and (7) implement the solution. The implications for revitalizing the technology education curriculum in schools are as follows: (1) technology education has a legitimate role in the school curriculum; (2) technology education will not be able to justify a position in the school curriculum by doing better what it has done in the past; (3) both academic and technology education have worthy content; (4) curricula should focus on the technological method; (5) technology education should justify its inclusion because of valuable unique content; and (6) teachers must be taught to modify and incorporate new philosophy and content into their programs. (Contains 25 references.) (CML)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED353400

Technology Education: Its Changing Role Within General Education

David J. Pucel
Professor
Department of Vocational and Technical Education
University of Minnesota
St. Paul, MN 55108
(612) 624-1736

American Vocational Education Association Convention
St. Louis, MO
December 6, 1992

CE062808

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

D J Pucel

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC).

BEST COPY AVAILABLE

The Problem

Society and the world of work have changed since the original development of vocational and industrial arts education during the industrial age. These changes have led to a rethinking of the role schools should play in preparing students to become technologically literate, and which components of the curriculum should be responsible. It is clear that most educators, and the public, believe schools should have a role in developing technological literacy, but how that role should be accomplished is not clear.

At one time most public schools had industrial arts programs, and in some states they were a mandatory part of the general education of all boys in the junior high school (middle school). Programs included courses in areas such as metalworking, woodworking, drafting, automechanics, and electricity. These programs were seen as fulfilling an important need for students entering an industrial world. However, as one examines the current decline of students enrolling in industrial arts and technology education programs throughout the country, and the decline in teachers preparing to become technology education teachers (Householder, 1992), it appears technology education as it currently exists is no longer perceived as meeting the technological literacy needs of students.

If the content of technology education is no longer viewed as contemporary and valuable, then presenting it as an option to students is not meaningful. Therefore, doing what we have done better does not appear to be the answer to ensuring the continuation of technology education programs in the schools. What is needed is a new rationale for technology education which defines a unique contribution which has value in today's society.

What has changed to make industrial arts and technology education of the past obsolete? At least two major changes have taken place. First, as society has evolved from the industrial age to the information age, the composition of the workforce has changed and the amount of training and breadth of education needed by students to be adequately prepared for jobs and to become technologically literate has increased (U.S. Department of Labor, 1991). Fewer and fewer people actually participate in production and service occupations requiring industrial age skills and practices. Therefore, industrial arts and industrial arts-based technology education programs have been viewed as less important in the general education of all students. Second, the new definitions of technologically literacy and continued pressure on academic subjects to teach in a more applied fashion have blurred the subject matter and teaching methodology distinctions between science, social studies, and technology education. This has caused many to wonder about the unique value of technology education. They ask, Doesn't science and social studies education develop the new technological literacy needed by students?

If technology education is to occupy a valued place in the school curriculum, satisfactory answers to questions like this are critical. Those answers will require a major philosophical shift in the goals of technology education. Technology education must clearly communicate its unique contribution to the education of students which goes beyond the content goals of science and social science education. Given that technology educators can accomplish this in a timely fashion, technology education can be assured of a continuing role in the general education of all students.

The Philosophical Base for Technology Education and the Past

The debate over the role of schools in developing technological literacy is not new. It took place at the turn of the century when industrial arts and vocational education originally received legitimacy in public schools. At that time technological literacy was defined in terms of basic practices of business and industry which were needed to understand and function within an industrial society. With the coming of the industrial revolution in the late 1800s and early 1900s it became increasingly clear that people needed to become familiar with the technology of the times in order to cope with it, and to adapt to new technology in order to become productive in the workplace. Industrialization required many people to work with machines and objects with which they were not familiar. Factories and mass production required people literate in utilizing industrial skills and practices; in other words the industrial arts. Schools were not prepared to offer the required education. They had historically focused on preparing students for citizenship and continuing education. Therefore, the issue of including education relative to technology in the curriculum was heavily debated. Proponents argued that,

> We live just as truly by the labor of the hand as by the labor of the head, and yet all the machinery of education from the primary school to the higher school is devoted to the cultivation of brain-power exclusively. The hands need training to make them efficient workers in the actual business of life, but our schools think it beneath them to train the hands. (Newell, 1878, p. 8)

With increasing pressure from society, curriculum was eventually introduced into the schools to provide students with options to prepare for employment and to become familiar

with the arts and practices of industry. Understandably, these curricular components concentrated on manual industrial practices with little emphasis on other types of skills.

The underlying assumptions of what constituted productivity in industry during the industrial age which influenced industrial arts education and vocational education are stated by Paul Strassmann as follows.

> The underlying assumptions about what "productivity" is go back to the industrial-age model of what a person, aided by a machine, does. (They were that) ...the handling of complexity requires information which is a manager's, not a worker's, prerogative. A person's superior coordination of eye and hand are what wages will purchase--until improved machines buy it for less. A person's brain is not a valuable asset per se under such assumptions, because the engineer designs into the manufacturing sequence everything which needs to be done. The employee's thinking is only useful insofar as it retains simple procedural instructions. (Strassmann, 1985, pp. 103-104)

Strassmann's position may be a little harsh, but it provides a frame of reference for the type of thinking that was in place when vocational and industrial arts education began. Obviously, this view is no longer held by people in industry or the schools. Not only have the skills needed to be successful in the workplace greatly expanded (Department of Labor, 1991), but there has been a growing concern for a broader view of technological literacy beyond the possession of skills for employment, or an appreciation of the arts and practices of business and industry.

The Need for Technological Literacy in Today's Society

There is a growing belief that technological literacy is at least as important today as it has been in the past, and that it should be addressed within the education of all students. Technological literacy is increasingly being seen as critical to the cultural literacy of all

citizens. Its development is also becoming recognized as requiring unique types of learning skills that can only be developed through hands-on sensory experiences with tools, equipment, ideas, processes and materials.

The perspective that technological literacy is critical to society is supported by philosophers who indicate, "It is...commonplace that modern science and technology...are leading forces of the time..." (Rapp, 1989, p. x). It is also supported by the scientific community which indicated that technology, defined as "the application of knowledge, tools, and skills to solve practical problems and extend human capabilities" (Johnson, 1989, p. 1), impacts all of us. They go on to say that, "The nation has yet to act decisively enough in preparing young people--especially the minority children on whom the nation's future is coming to depend--for a world that continues to change radically in response to the rapid growth of scientific knowledge and technological power" (Johnson, 1989, p. vii).

The consequences of a citizenry which is not technological literate are also being discussed. There is a growing belief that if citizens do have adequate backgrounds in fundamental technology which lead to a level of cultural technological literacy, different individuals will be at widely varied places when discussing or adapting technology related to their lives or work. Those who are technologically literate will be at an advantage over those who are not. Those who are technologically literate will view technology as a tool to accomplish goals, those who are not will be "technopeasants". Sarkikoski indicates,

> Technology has always presented two faces to society. On the one hand technological innovations have been seen to satisfy objective social needs, and technologists have been regarded as altruistic servants of society in a spirit of professionalism...On the other hand, ideologically or politically, technology has played an important role in social processes...Those who reproduce technological ideas and structures, i.e., the producers and users of

> technological knowledge, also formulate patterns of social conditions and consciousness. (Sarkikoski, 1988, p. 341)

It is clear that just as there was a need for technological literacy at the turn of the century, there is a renewed argument that technological literacy is essential for all citizens. The question is, what does technological literacy mean in today's society and what is the unique role for technology education?

Differentiating Technology From Science and Social Science and Other Areas of the School Curriculum

Many other subject matter areas claim to address technology from one or more perspectives. Why is there confusion? One area of confusion is the differences between science and social science, and technology education. Often people have the mistaken notion that technology is just the application of science. If philosophers and educators consider technology as only applied science, they minimize the need to consider it as having important content of its own. Recently, scholars have begun to clearly differentiate science from technology, which in turn facilitates more precise definitions of instructional programs designed specifically to enhance technological literacy. They have also begun to more clearly explain why the development of technological literacy requires learning activities and processes different from those typically used to teach the liberal arts or other subjects in the schools.

Rapp (1989, p. x), a philosopher, indicated, "Clearly the structure of thinking in technological sciences, as well as the methodological principles of design and of efficient and purposeful action exhibit patterns of their own which differentiate science from technology."

The Project 2061 panel of scientists indicated technology is "...different from science, whose role is understanding. Technology's role is doing, making and implementing things. The principles of science, whether discovered or not, underlie technology. The results and actions of technology are subject to the laws of nature, even though technology has often preceded or even spawned the discovery of the science on which it is based" (Johnson, 1989, p. 1). For example, people knew logs would float and if they put them together in a raft they could move things over the water. They did this without understanding the scientific principles underlying buoyancy. The later scientific explanation of why rafts float was useful in making boats and other things float. But such scientific knowledge was not needed to create the original raft technology. Native Americans knew they could brew a tea from the bark of aspen or willow trees and that the tea would help headaches and fevers. Later, scientists interested in this phenomenon found the bark contained the same chemical found in aspirins. The native Americans did not need to know that aspirin would help with headaches and fevers and that the bark of the trees contained the same chemicals so they should brew a tea. In both of these cases a technology (technical means of providing a solution to a human need) occurred before science could explain how and why it worked. In other words, it is being argued that there are unique thinking patterns and processes for creating technical solutions to human needs that students should understand that go beyond the application of science.

In addition to science courses, schools also contain other programs which are sometimes confused with fulfilling the need for technology education. Each provides complimentary knowledge about technology, but each does not fulfill the primary goals of

technology education. Social studies programs often include descriptions of the historical impact of technological innovations upon society; practical arts programs such as traditional industrial arts, general business, general agriculture, general home economics, and vocational education programs often teach students selected practices applied to work and family. However, none of these programs currently present a comprehensive technology education program with the primary purpose of students becoming technologically literate. They all have other primary purposes (e.g., history, scientific principles, occupational skills, industrial practices).

The distinctions between other areas of the curriculum and technology education are further confused by past attempts by technology educators to justify their position in the schools as a means of applied learning. In other words, technology education is sometimes justified as an applied environment for teaching math, science and social science. This worked to some extent when academic subjects tended to rely on drill and practice and memorization without attempting to apply what was being taught to life and work. However, this is changing. While the role technology education programs in schools has been challenged, the relevance of academic programs to students needs has also been challenged. An increasing number of academic educators are advocating that their programs be re-designed to make them more functionally related to society. They still believe there is a need to concentrate on academic basics, but suggest a need to teach those basics in a more functional manner. This change has been supported by a number of academic subject groups such as the National Council of Teachers of Mathematics (Kurtz et.al., 1990), and the National Center for Improving Science Education (National Center for Improving Science

Education, 1989). Support for making all school curricula more functionally related to life and work has also come from the national movement advocating that all educational programs be outcome-based, which requires the specification of the outcomes students will be expected to attain upon completing the programs (Spady & Marshall, 1991).

Consistent with these movements to make academic courses more applied, The Center for Occupational Research and Development (CORD) has developed a set of applied science, math and communications courses. Their "principles of technology" curriculum is an applied physics course built around teaching physics using occupational examples (Edling, 1992). Some technology educators have embraced these programs as alternatives to industrial arts or technology education programs. In doing so they have embraced the false notion that technology education is essentially applied science.

If academic educators accept the challenge of applied learning, the role of technology education as an alternative vehicle for learning academic content will be greatly reduced, and so will the perceived value of technology education. This movement of some technology educators toward suggesting technology education as an alternative vehicles for teaching academic subjects may be an excellent way to make the academic subjects more relevant to everyday life and employment, however, it implies that there is no content unique to technology education.

The Role of Technology Literacy in Cultural Literacy

The key to defining a unique role for technology education in the schools is a clear understanding of technological literacy and how it is developed. With this understanding it

becomes apparent that other areas of the school curriculum are not equipped to develop the technological literacy required in today's society. The definition of technological literacy, as referred to here, was derived by reviewing the literature regarding the role of technology in society (Bailey, 1978; Gardner, 1964; Rapp, 1989; Sarkikoski, 1989; Savage & Sterry, 1990) and the report of the Project 2061 Panel of scientist (Johnson, 1989). The panel indicated that technology education should reveal the process of technology as it evolves from ideas to fruition, and that such education should show how technology affects individuals and society. They further indicated, technology is defined as "the application of knowledge, tools, and skills to solve practical problems and to extend human capabilities" (Johnson, 1989, p. 1). Based on the review, a synthesized definition of technological literacy was developed. "Technological literacy is the possession of understandings of technological evolution and innovation, and the ability to apply tools, equipment, ideas, processes and materials to the satisfactory solution of human needs" (Pucel, 1992, p 3).

Technological literacy is part of cultural literacy. "To be culturally literate is to possess the basic information needed to thrive in the modern world" (Hirsch, 1988, p. xiii). The possession of such information is critical to individuals living in a society. Experiments in language have shown that people within a culture "...always go beyond a text's literal meanings to supply important implications that were not explicitly stated by the words of the text" (Hirsch, 1988, p. 39). Therefore, depending upon the background information different people have, although they can read the words in a sentence equally well, they will derive different meanings based on past learning and experience. For example, a person who reads the sentence "A boy is riding in a car" will envision one thing if the only car the

person experienced was a limousine capable of carrying eight people. The person will envision something else if the only car experienced was a one-seat racing car. Both visions will be more similar if both people have only seen a one-seat racing car. It is difficult to determine what they will envision if neither ever saw a car or heard of one before. It is this concept of attaching meaning based on past learning and experience which has led to the belief that certain common content elements should be taught to all citizens. It is the possession of these common reference points that allow different individuals within a culture to communicate effectively.

As technology has become more pervasive in our society, common understandings and reference points regarding technology have become increasingly important as part of cultural literacy. During everyday conversation, assumptions are being made about a person's basic understanding of technology. Those assumptions affect expectations regarding a person's ability to understand discussions involving technology. For example, if a person is asked to adjust a roller with a screw driver, the assumption is that the person not only knows what the word "adjust" means but has a sensory knowledge of adjusting. This means that the individual has a sense for such things as what to look for to determine if it is adjusted, a feel for what it means for a screw to be tight but not so tight the screw breaks, and that the person can select a screwdriver and use it correctly.

The possession of such common fundamental technological understandings and experiences can build a sound foundation for a technologically literate citizenry. Therefore, the content selected for a general education program focused on technological literacy should focus on content which builds such a foundation. The challenge is to develop a clear notion

of what types of experiences and knowledge are necessary to be technologically literate within our society today.

The Content and Learning Methods of Technology Education

Given that technology has a content of its own, what should people know and be able to do to be technologically literate? Technologically literate people have two primary characteristics, based on the definition of technological literacy presented earlier. First, they have developed common sense knowledge of technology based on experiences with tools, equipment, ideas, processes and materials. Second, they understand the method through which technology develops and evolves to satisfy human needs. It is these two areas that can form the content base for technology education.

Common Sense Technological Knowledge

Common sense knowledge of technology includes the basic understandings and abilities to use technology that are necessary as part of cultural literacy. This common sense knowledge becomes basic background knowledge that is used as an almost automatic reference point in deriving meaning regarding technological applications in the culture. This common sense knowledge is developed through both language-based and sensory-based learning. Language-based knowledge includes understandings developed through books, lectures, discussions and other forms of verbal interactions. Sensory-based knowledge includes understandings and abilities developed through real physical and visual interactions with the tools, equipment, ideas, process and materials of technology.

The term "common sense knowledge" was suggested by Hubert Dreyfus from the University of California, Berkeley, and by computer programmers trying to develop artificial intelligence programs designed to simulate human thinking (WGBH Boston, 1992). They found it virtually impossible to program a computer to simulate sophisticated human thinking. Even simple children's stories could not be understood by a computer. After extensive investigation they determined that this was not due to what they told the computer, but what they did not. They found that humans develop almost endless amounts of common sense knowledge which is assumed during communication. Common sense knowledge is that knowledge which people learn through living and experiences (including education) which provides contextual information within which things around them are interpreted and manipulated. In other words, common sense knowledge is the basis for what Hirsch calls cultural literacy.

Whereas computers have to be taught all knowledge needed to operate with a given set of problem situations, people only need to be taught additional information on the fringes of what they already know. The new material is given meaning within the context of material previous learned. The researchers concluded that, "General human intelligence somehow creates a broad model of the world enabling us to cope with all kinds of situations" (WGBH Boston, 1992). They were providing essentially the same arguments that Hirsch did in his justification of the need for cultural literacy. However, they framed their arguments in terms of sensory-based as well as language-based knowledge.

Common sense knowledge of technology is what is needed by the American public as a basic foundation from which to understand, monitor and work with technology. It is this

general knowledge of technology that allows technologists to understand and apply technology while those who do not have this knowledge view technology as a mystery and become peasants of technology. Such knowledge becomes a critical part of the base for technological literacy upon which all citizens can more completely participate in a technological society. The development of this common sense knowledge could be a unique role for technology education in the schools.

Learning Common Sense Technological Knowledge

How does a person develop common sense knowledge of technology? The answer to this question gives direction to how to teach for technological literacy.

It is becoming increasingly clear that developing a functional understanding of technology requires experiences which go beyond language-based activities typically presented in schools. Engineers, architects, skilled workers and others who apply technology have repeatedly argued that teaching people about technology must include hands-on experiences. However, the reasons why hands-on experiences are critical to such learning have only recently been clearly articulated. The work of the computer scientists helps provide a more concrete rationale.

As the study of artificial intelligence has progressed, it has also become increasingly apparent that real common sense knowledge not only requires a set of rules and facts that can be communicated through language, but a human body capable of sensing and developing a set of experiential skills. With experience, some of these skills become semi-automatic responses when a person encounters similar situations. The computer researchers supported this contention by viewing children at play with such common things as blocks, sand and

water. They found that children spend hours and years playing with these same things. They suggest that this play has meaning in forming common sense knowledge about each of these objects. The thousands of experiences with pouring, spilling and filling things with water were not all stored in memory as separate cases. They were stored in the brain as a set of neuron charges. When similar situations occurred later in life, individuals adapt almost automatically. With this understanding of common sense knowledge and how it develops, computer scientists are now trying to teach computers through visual inputs which allow the computers to sense, store and generalize from what they see and experience. They are finding that such input allows computers to do things which they were not able to direct computers to do through language and language-based rules.

If people are to develop common sense knowledge of technology, they must also be presented experiences which will allow them to work with the tools, equipment, ideas, processes and materials of technologists. These experiences need not be directed at preparing occupational level competence. The experiences could be examples of technology which have generalizability to many technological applications. Just as children do not think they are developing work skills when they play with water, those skills are applicable to the work of a chemist, photographer, mechanic, and homemaker. Similar experiences with common technology can facilitate the ability of individuals to apply technology during their lives and work.

John Brockway (1989), an experimental psychologist, in a speech to the Sloan Foundation, provided additional support for the need for technology education programs to be more than just programs presented through standard language-based textbooks and typical

classrooms. He also supported the belief that students need to be taught to learn through their senses as well as through language. He indicated, "...thought patterns of thinkers in liberal arts colleges are distinctly different from the predominant operative thought patterns employed in major institutes of technology" (p. 1). He suggested, "...that the core of the domain of liberal arts thinking is textually-based, linguistically-controlled, and delivered orally and verbally in writing" (p. 2) with no major emphasis placed on thinking visually. In contrast he suggested technologists' thought processes deal with images and thinking that are driven predominantly by visual processes. He points to people who read blueprints, observe radar screens, read tables, and inspect real items to determine how they work and how to repair them as all deriving knowledge in non-verbal ways. Brockway's observations support the conclusions of the computer scientists that knowledge is developed through a combination of verbal communications and the senses. He suggests this is why people say a picture is worth a 1,000 words. The picture presents spatial relationships as well as contextual information which is visually interpreted all at the same time. He suggests that people who are taught to obtain knowledge through visual stimuli can derive meaning even if they do not know the words associated with what they see. They have a more complete set of learning skills than those who are only taught using verbal and written language. The development of this more complete set of learning skills based on sensory learning should be a primary goal of a technological literacy program.

The Technological Method

A second major content component of any technological literacy program (in addition to sensory-based experiential learning with tools, equipment, ideas, process and materials) is

content leading to an understanding of how technology evolves and how it is developed to meet human needs. The Project 2061 Panel indicated that technology education should reveal the process of technology as it evolves from ideas to fruition, and that such education should show how technology affects individuals and society (Johnson, 1989). The accomplishment of this goal requires a new organizer and vehicle for teaching technology that will ensure an understanding of this process. The importance of common sense knowledge of technology developed through language-based and sensory-based experience is given context by understanding that such knowledge is usefully applied to satisfying human needs. The new organizer must provide a general model for viewing the application of technology within modern society.

Just as the scientific method has helped people understand the role of science and how science evolves, a clearly stated technological method can help people understand the role of technology and how it evolves. The following proposed "technological method" is similar in function to the scientific method. It helps explain the fundamental relationships among the many forces which influence technological evolution and innovation that operate within society. It provides a basis for organizing learning experiences and the presentation of activities to develop common sense knowledge of technology within a technology education program.

Whereas the scientific method is generally acknowledged as the principles and procedures for the systematic pursuit of new knowledge, the proposed technological method is a set of principles and procedures for the systematic development of socially acceptable

technical solutions to human problems. The scientific method is typically presented as having four basic steps:

1. Recognize and formulate a problem in terms of understanding relationships between events or phenomenon;
2. state hypotheses which express expected relationships;
3. gather data through observation and experimentation to prove or disprove the hypotheses; and,
4. draw conclusions and generalizations focused on providing an explanation of the findings in terms of the relationships.

In contrast, the proposed technological method involves seven basic steps focused on deriving satisfactory technical solutions to human needs. The method was developed based on a one week visit by the author to the American History Museum of the Smithsonian Institution in Washington D.C. to speak with museum personnel and to observe the historical technological developments in computer, communication, transportation, office and agricultural technology. In addition, literature on the processes of invention (Caney, 1985; Doster, Goodwin, & Ross, 1978; Hindle, & Lubar, 1986; Mayr, & Post, 1981; Turvey, 1992), creative engineering (Bailey, 1978), and the interactions between technological change and society were synthesized (Bailey, 1978; Gardner, 1964; Johnson, 1989; Rapp, 1989; Sarkikoski, 1989; Savage & Sterry, 1990). The "technological method" is presented as a set of generic steps which can be applied to any area of technology. The steps are:

1. Identify an unmet human need requiring a technical solution (e.g., product, system, design);
2. clarify the specific technical problem;
3. identify relevant existing technical methods and knowledge;
4. invent a probable solution;
5. determine the social acceptability and economic feasibility of the solution;
6. modify the solution if needed to maximize efficiency and acceptability; and,
7. implement the solution.

Both the scientific and technological methods are not intended to depict the exact processes used by expert scientists or technologists as they practice. However, they are generic representations of the major steps used by scientists as a group, or technologists as a group. Even though the technological method is acknowledged as not being absolutely definitive and totally inclusive, it does present a set of generic developmental steps used by technologists which can be used as a basis for introducing students to technology. A detailed description of sub-steps within the technological method and examples can be found in (Pucel, 1992).

The "technological method", as an organizer for technology education, differs in important ways from other proposed technological methods. The method focuses on the belief that technology evolves to serve functional purposes defined as useful by humans. It focuses on the interaction between the technical aspects of solutions for meeting needs and the social and economic aspects of appropriate solutions. It presents technology as a vehicle for enhancing the quality of human existence. In contrast, the methodology proposed by Savage & Sterry (1990) is based on the belief that technology should be studied because of "...the dependence of humans on technical means for survival..." (p. 7). That model does not explicitly recognize technology's role in doing something better, or in improving the quality of life, including leisure. The Savage & Sterry model also presents the technological method as being synonymous with the problem solving method. They suggest that "The process of problem solving provides the parallel in technology to the scientific method in science" (Savage & Sterry, 1990, p. 15). Although the technological method is in fact a problem solving method, it has unique characteristics which are not explicitly addressed

during the application of a generic problem solving method. Those characteristics must be explicitly addressed in a technological method to reflect the unique aspects of technological problem solving as a basis for a technology education program. Although the preamble to the Savage & Sterry model accepts many forces which influence the development of technology, their six step method concentrates on the technical solution. Therefore, that method does not adequately integrate important variables which students must envision (e.g., socio-economic variables) when thinking about technological evolution and innovation.

The "technological method" also differs from the 16 steps proposed by the Project 2061 panel (Johnson, 1989, p. 3). The 16 steps concentrate on finite questions which engineers should address in designing a new technology. However, they are not easily generalizable to less highly planned technological invention which occurs without extensive amounts of preplanning. For example, the development of a space shuttle or a new bridge requires the type of preplanning performed by engineers. However, the on-the-spot improvisation needed to make a lawn mower operate does not. Even though highly planned and improvised solutions differ in the precise steps taken to develop solutions, both follow the same generalizable technological method of evolving solutions to human needs.

The technological method is also explicitly based on the processes of innovation, hence invention. Although this might be implied in the other proposed methods, it is not inherently built into their methodologies. To invent implies fabricating something useful as a result of ingenious thinking or experimentation. This is a primary characteristic of technology. It is different from creation which implies an evoking of life out of nothing or producing a thing for the sake of its existence rather than its function. It is also different

from discovery which supposes the pre-existence of something and implies a finding rather than a making. That which is invented may be a product like a new type of television, or a system such as a production process or system for managing people. The new solution may be as major as the invention of the microchip, which allowed for the miniaturization of computers, or as small as a new fastener which more effectively holds tablecloths on tables. The invention may influence the evolution of many areas of technology or only one. The invention may solve an immediate problem for only one person or a long-range problem for many.

Specific Technology Education Content for All Students

A general discussion of technological literacy and its relationships to cultural literacy and society were presented earlier in this paper. Also detailed discussions of common sense technological knowledge and the technological method were presented. Given those contexts, this section focuses on defining the specific technological content that should be included in a basic technology education program to develop technological literacy.

Technological Method as Content

A major technological literacy content component is the "technological method" presented earlier. Understanding this method allows individuals to comprehend how technology evolves and develops and its relationship to societal development. Therefore, teaching the method as content becomes important. However, developing an understanding of the method alone is not sufficient to prepare a technologically literate individual.

In addition, the method provides the framework for teaching for technological literacy. Other technological content can be taught within the contextual framework of the technological method. The development of technical solutions can form the context within which students are allowed to experience the application of technical tools, equipment, ideas, materials and processes in laboratory situations to develop both language-based and common sense technological knowledge.

Areas of Technology

What are the technological areas with which students should become familiar? Project 2061 identified 11 technologies important to modern society (Johnson, 1989, pp. 13-28). They were:

materials
energy
manufacturing
agriculture and food
biotechnology and medical technology
environmental (atmosphere)
communications
electronics
computer technology
transportation
space

Traditionally, technology educators have classified technologies into power, transportation, manufacturing, construction and communications (Warner, 1965). Warner also included management in his original works. More recently they have included other areas such as biological technology (Savage & Sterry, 1990). Regardless of the specific list used, the challenge is to identify content that applies across technological areas as a basis for creating a technological literacy program worthy of being part of the general education of all students.

Common Threads Among Technology Areas

Based on a review by the author of materials from a range of technological areas, two common threads which might serve as bases for developing an instructional program to be taught within the context of the technological method have evolved. They are designing and producing technical solutions. At times designs themselves may be viewed as the technical solution (e.g., organization chart, blueprint, flow chart). At other times designs are viewed as interim processes necessary in the development of physical apparatus. Whether designs are the solutions, or part of the process of arriving at solutions, is determined by the need originally expressed. For example, engineers, architects and systems designers are often called upon to produce solutions in the form of plans or designs. Craftsmen are often called upon to produce solutions in terms of a physical apparatus (e.g., machine, house, duplicator, blood analyzer).

Obviously, in addition to these common threads across technologies, the different technological areas also have unique content that govern the shape, form and substance of designs and physical apparatus. For example, a plan for a computer programmer might be a flow chart while the plan for an engineer might be a set of blueprints. Physical apparatus in medical technology solutions might be a CatScan or a heart catheter, while a physical solution in electronics might be a circuit, and in carpentry a new technique for assembling a house. Even though some of the specifics of designing and developing physical apparatus vary between technological areas, solutions require the same basic planning techniques and the need to manipulate tools, equipment, ideas, processes and materials.

It is these common threads among the technologies that provide the most fruitful vehicles for conveying common sense technological knowledge as part of the cultural literacy of all students. These common threads could be taught within the contexts of the various technological areas during the curriculum. This would provide students with an overview of the various technological areas and could make them aware that within all areas of technology, solutions are derived in a similar fashion and that each area also has unique variations. The primary content would be centered on the design and development of physical apparatus solutions focused on satisfying human needs.

This recommendation is made in full recognition that solutions which result in designs or physical apparatus do not cover all of the possible types of solutions in each technological area. Later in the school curriculum, or in post-secondary education, students could be provided with opportunities to elect to study specific technologies in more depth.

Ten Categories of Technological Content

Assuming the most fruitful foci for a general course in technology education are the technological method; and the tools, equipment, ideas, processes and materials for designing or producing physical apparatus solutions, the 10 categories of content presented in Table 1 are recommended. Suggested ways of teaching this content are beyond the scope of this paper. However, they can be found in the paper entitled "Technology Education: A Critical Literacy Requirement For All Students" (Pucel, 1992). The first six categories of content presented in Table 2 should be the primary focus of the technology education program. Although the last four categories must be addressed and reinforced by technology educators in implementing instruction within the technological method, primary responsibility for

Table 1

Ten Categories of Technology Education Content

Primary

1. technological method (including the invention process)
2. common tool usage (e.g., screwdrivers, wrenches, meters, vises, clamps, t-square,
   compass, beaker)
3. common equipment (e.g., drill press, sander, table saw, welder, generator, robot,
   drafting machine, computer, balance scale)
4. basic technological process (e.g., fastening, cutting, shaping, propagating, mixing,
   measuring)
5. materials (e.g., metals, plastics, wood, composites, paper, fiber, cellulose)
6. terminology (e.g., circuit, flow, kerf, voltage, bonding, adhesion, center-line, hybrid, open-system, contaminants)

Applied and Reinforced

7. environmental concerns (e.g., pollution, resource consumption, disposal)
8. social values (e.g., preserve jobs, prejudices, moral implications)
9. scientific principles (e.g., friction, electricity, leverage, nuclear energy, genetics)
10. economic factors (e.g., supply, demand, costs, benefits, return on investment)

teaching that content in schools should be the responsibility of other areas of the curriculum (e.g., science, math, social studies). This distinction is important in the development of a general technology education program. Given the limited amount of time available, and what can be reasonably expected of a technology education instructor, the content expectations of a technology education program must be realistic. It is not possible to teach all of the content in each of these 10 categories in-depth within a limited technology education program. It is also not possible for one instructor to be adequately prepared to teach all of these subjects. In order for schools to accomplish the broad goal of preparing students to enter a

technological society, all areas of the curriculum must cooperate while teaching their own unique content. This may require jointly planned curriculum across the subject matter areas.

Implications for Revitalizing the Curricula

The major challenge to technology education is to identify and justify unique roles it can play in the development of technological literacy that will warrant curricular space in schools. Technology educators must identify their unique content and how they can work with other subject areas in the school to teach that content, while reinforcing the content taught by other subject matter areas. All subject matter areas of the school curriculum are justified based on the value of their content in preparing students for the future. Without unique content of value, technology education programs are not likely to survive.

This paper presented a rationale for the need for technological literacy and how technology education can play a unique and crucial role in its development. It acknowledged the need for cooperation between academic and technology education programs, but it also suggested a body of content which is unique to technology education that should be required of all students as part of their cultural literacy. That body of content included the technological method and how it can be used as a vehicle to teach technological innovation and evolution, and common uses of tools, equipment, ideas, processes and materials to provide solutions to human needs. The implications for revitalizing the technology education curriculum in schools are summarized as follows.

1. There is a legitimate role for technology education in the school curriculum. Important groups are supporting the need for schools to develop technological literacy as part of cultural literacy. However, those groups are calling for substantial

changes. Bruce Gray, Superintendent of the Francis Tuttle Vocational Technical Center in Oklahoma City suggests, "Any real change will require that individuals...quit worrying about protecting...turf and start focussing on common goals" (Gray, 1992, p. 23).

2. Technology education will not be able to justify a position in the school curriculum by doing what it has done in the past better. Society and societal expectations, as well as the world of work have changed substantially. Therefore, the programs are facing a new context to which they will have to adjust. Once satisfactory programs have been developed, their place in the curriculum will have to be re-justified. Most adults have well developed perceptions of industrial arts and technology education based on past personal experience. Therefore, leaders must not only talk to people in the field, but must communicate with the public and decision makers to change public opinion and perception.

3. New technology education curricula should be developed in full recognition that academic, as well as technology education programs each have unique content worthy of being taught in schools, and that each can contribute to the technological literacy of students.

4. Technology education curricula should be revised to focus on the technological method, which includes the notion that technology is a means of meeting human needs with consequences to society, as well as technical skills and knowledges. The focus should be on developing common sense knowledge of technology as part of cultural literacy and not on the development of occupational skill competence.

5. Technology education should not justify its existence by claiming to be an alternative way of teaching academic skills. It should justify its inclusion in the school curriculum on the basis of valuable unique content, as is required of other areas of the curriculum. On the other hand, technology education should highlight its ability to reinforce academic skills in concrete ways as its unique content is taught.

6. In order to revitalize curricula, existing industrial arts and technology education teachers, and new teachers must be taught how to modify and incorporate the new technology education philosophy and content into their programs. They must be provided alternative program rationales and curriculum strategies which they can use to advocate and modify local programs.

References

Bailey, R. L. (1978). Disciplined creativity for engineers. Ann Arbor, MI: Ann Arbor Science Publishers.

Brockway, J. P. (August 11, 1989). Technology & the liberal arts: Mixing differing thought patterns. Wellesley, MA: Wellesley College, Alfred P. Sloan New Liberal Arts Program.

Caney, S. (1985). Steven Caney's invention book. New York, NY: Workman Publishing.

Doster, A., III, Goodwin, J., & Ross, J. M. (Eds.). (1978). The Smithsonian book of invention. Washington, DC: Smithsonian Institution Press.

Edling, W. (1992). Tech Prep/Associate Degree Program: TPAD. Waco, TX: Center for Occupational Research and Development.

Gardner, J. W. (1964). Self-renewal: The individual and the innovative society. New York, NY: Harper & Row Publishers.

Gray, B. (1992). Voices of change. Vocational Education Journal, 67(7), 23.

Hindle, B., & Lubar, S. (1986). Engines of change: The American Revolution, 1790-1860. Washington, DC: Smithsonian Institution Press.

Hirsch, E. D., Jr. (1988). Cultural literacy: What every American needs to know. New York, NY: Vintage Books.

Householder, D. (1992). Assessing teacher education programs. Presentation to the 1992 Mississippi Valley Industrial Education Conference, Chicago, IL.

Johnson, J. (1989). Technology: Report of the project 2061 phase I technology panel. Washington, DC: American Association for the Advancement of Science.

Kurtz, V. R., et al. (1990, October). Special issue. School Science and Mathematics, 90(6), 451-574.

Mayr, O., & Post, R. C. (Eds.) (1981). Yankee enterprise: The rise of the American system of manufacturers. Washington, DC: Smithsonian Institution Press.

National Center for Improving Science Education. (1989). Science and technology education for the elementary years: Framework for curriculum and instruction. Andover, MA: The Network.

Newell, M. A. (1878). Proceedings of the American Institute of Instruction.

Pucel, D. J. (1992). Technology Education: A critical literacy requirement for all students. Presentation to the 1992 Mississippi Valley Industrial Education Conference, Chicago, IL.

Rapp, F. (1989). Introduction: General perspectives of the complexity of philosophy of technology. In Paul T. Durbin (Ed.), Philosophy of Technology (p. ix-xxiv). Holland: D. Reidel.

Sarkikoski, T. (1989). Re-orientation in systems thinking?--Some remarks on the methodological and ideological traits of technological reproduction. European Journal of Engineering Education, 13(3), 341-348.

Savage, E., & Sterry, L. (1990). A conceptual framework for technology education. Reston, VA: International Technology Association.

Spady, W. G., & Marshall, K. J. (1991). Beyond traditional outcome-based education. Educational Leadership, 49(2), 67-72.

Strassmann, P. A. (1985). Information Payoff. New York: Free Press, Macmillan, Inc.

Turvey, P. (1992). Timelines inventions: Inventors & ingenious ideas. New York, NY: Franklin Watts.

Warner, W. E., et al. (1965). A curriculum to reflect technology. Columbus, OH: Epsilon Pi Tau, Inc.

WGBH Boston. (1992). The machine that changed the world. Boston, MA: WGBH Boston/BBC TV Corporation in Association with NDR Hamburg, WGBH Educational Foundation TV series.

U.S. Department of Labor. (1991, June). What work requires of schools: A SCANS report for AMERICA 2000. Washington, DC: U.S. Government Printing Office.